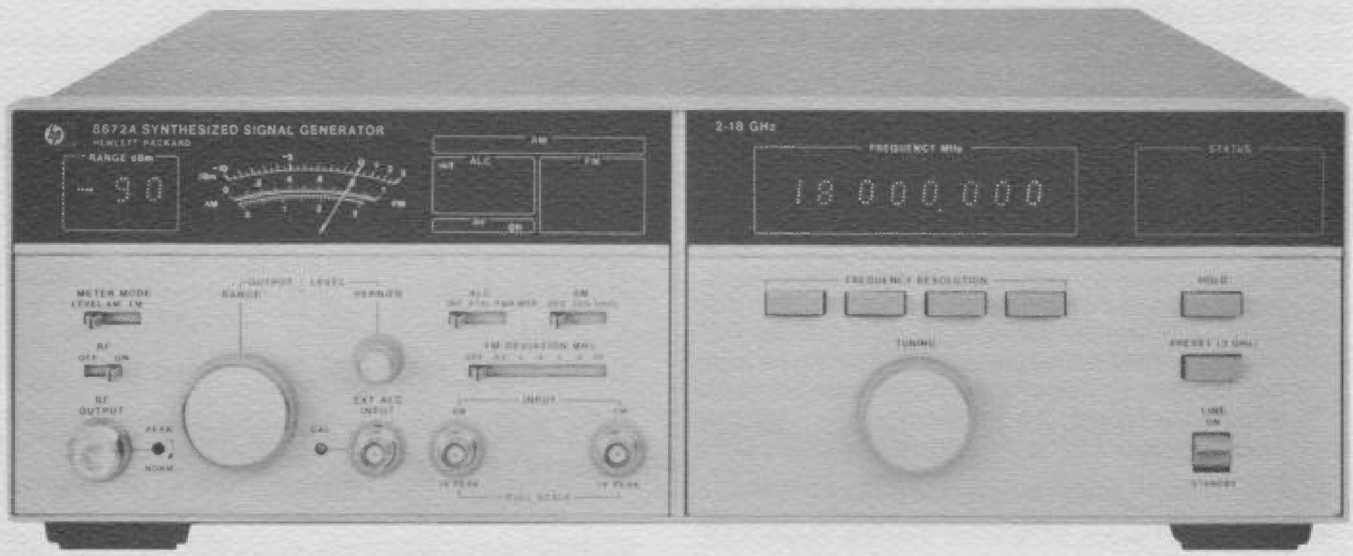
8672A Synthesized Signal Generator ⟷ HP-IB ⟷ HP 1000 Computer

Programming Guide

HEWLETT hp PACKARD

Application Note 401-15



Device Introduction

The 8672A Synthesized Signal Generator is an extremely pure frequency source which covers the entire 2.0 to 18.0 GHz frequency range with a single output. It not only has wide frequency coverage, but also combines synthesizer accuracy, spectral purity, and programmability with the precise modulation and output level calibration of a signal generator. The 8672A has two ranges of metered amplitude modulation, and six ranges of metered frequency modulation. The output frequency is always phase-locked while modulation is applied, and simultaneous AM and FM is possible. Output power is internally leveled and calibrated from +3 to −120 dBm for making receiver sensitivity tests and may also be externally leveled from either a diode detector or power meter.

The 8672A is fully programmable.[1] All front panel functions except the line and meter mode switches can be HP-IB controlled. Frequency can be programmed to the same resolution as in the manual mode. The output level is programmable over its full range in 1 dB steps, or it can be programmed OFF. The choice of leveling sources (internal, external, crystal, etc.) can be remotely controlled. The modulation and range can also be remotely controlled. When in remote, all front panel controls are disabled except the meter mode and line switches.

[1]*See the Operating and Service Manual for the 8672A (part number 08672-90058).*

The 8672A will accept any programmed frequency within its output range to 1 kHz resolution. Above 6.2 GHz, the 8672A will round up or down if the programmed frequency is not compatible with the 2 or 3 kHz resolution actually possible.

The 8672A will send a status byte containing critical information on the instrument's operation when addressed to talk. It will also request service (SRQ) when normal operation is disrupted.

Addressing

In the 8672A, the HP-IB talk and listen address is selectable. The address switches are located on the A2A9 board assembly. This assembly also contains the parallel poll sense and response switches. To set the address and parallel poll switches, perform the following steps:

a. Disconnect the power line.

b. Disconnect any HP-IB cables from the HP-IB connector.

c. Remove the two top rear feet and the Pozidriv screw holding the top cover, and remove the cover. (The screw is held captive by the cover.)

d. Remove the Pozidriv screw holding the A2 cover plate. Then lift up the protective cover and slide it towards the rear of the synthesizer to allow the front edge pins to disengage from the guide slots, and set the cover aside.

e. Remove the A2A9 board assembly. It is located in the middle of the A2 section. (See illustration on the A2 cover or figure 15-1.)

f. Set the HP-IB address desired on switches S2 and S3. They are rotary switches marked in octal notation: S3 is the high order digit, and S2 is the low order digit. For example, the address set by the factory is 23 (octal). The "2" is set on S3, and the "3" is set on S2. The decimal equivalent of this is 19.

g. Set the Parallel Poll Sense switch (three-position rotary switch, S4) to either the OFF, 0, or 1 position. OFF disables parallel poll responses. The 0 setting reverses the response, so that a "0" response is the affirmative response to the poll. The 1 position causes a standard response where a "1" is the affirmative response to the poll.

h. Set the PPR switch, S1, to select a number between 1-8. The selected number is the line which will contain the synthesizer response to a parallel poll.

i. Re-install the A2A9 board assembly.

j. Replace the A2 assembly internal cover, top cover, and rear feet.

k. Connect the power and HP-IB cables.

LU Assignment

One logical unit number (LU) should be assigned to the 8672A after setting the switches. From File Manager,

```
:SYLU,19,10,23B
```

will assign LU 19 to equipment table 10. The device address associated with LU 19 will be 23 octal.

Buffering

The buffering option for the 8672A EQT is not needed. It should be turned off.

```
:SYEQ,10,UN
```

would set the equipment table in the above example to the unbuffered mode.

Remember, the bus must be unbuffered if the user program performs its own error checking.

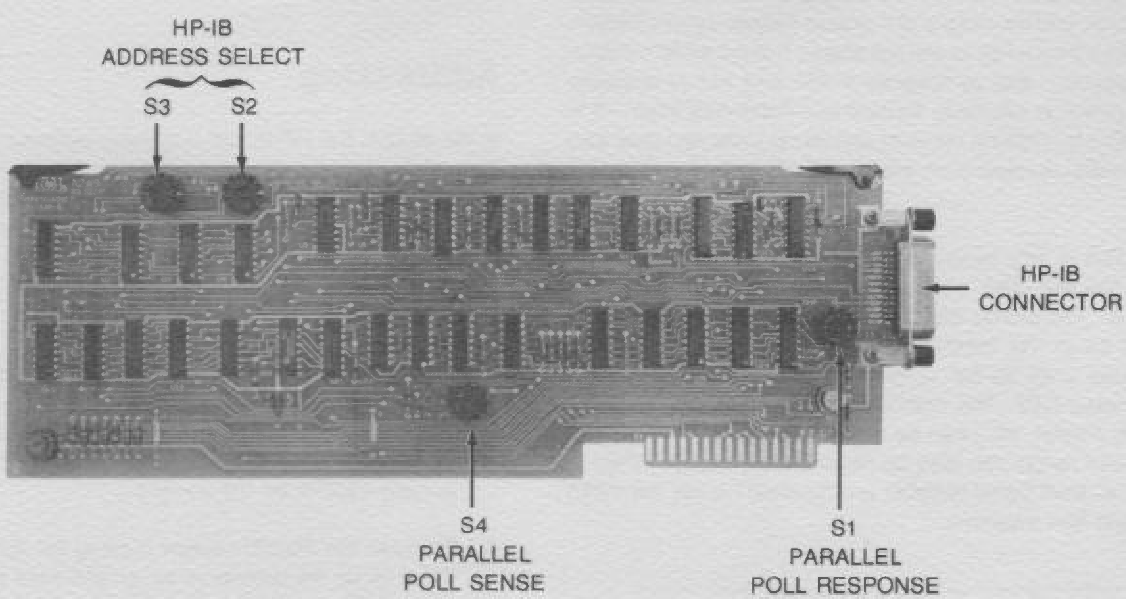


Figure 15-1. Layout of the A2A9 Printed Circuit Board

Time-out

In certain cases, the 8672A can delay a response for up to 50 milliseconds. Any longer delay from the 8672A is considered to be a time-out error. When selecting a time-out value, remember that the time-out value will affect all devices on the same EQT, and should encompass the needs of all these devices.

From File Manager, a system request may be used to set the time-out value:

```
:SYTO,10,100
```

will set the time-out on EQT 10 to 1 second.

A time-out condition will be handled through RTE by default. However, the user program may handle the situation by setting up the device configuration word accordingly.

When bit six (the E bit) of the configuration word is zero, the operating system will set the logical unit of the 8672A down after a time-out, and put the user program into the general wait state until the "UP" operator request is entered from a user terminal. When the E bit is configured to one, the time-out will not stop execution of the user program. Instead, the current bus status should be checked (by calling the subroutine "IBERR") each time an I/O request is made to determine whether the time-out occurred.

Two examples of the device configuration word are shown in figure 15-2 — one for operating system processing of the time-out condition, and the other for user program processing of the error.[2]

A File Manager request may be used to adjust the error bit in the device configuration word. If the LU to be configured is 19,

```
:CN,19,25B,17400B
```

declares that time-out processing will be performed by the user program. Other bits also have specific meanings, as described next in "Configuration."

Configuration

The device configuration word should be examined for possible changes to the default mode.

The 8672A is capable of detecting instrument errors and reporting the condition to the HP 1000 by asserting the SRQ line. The HP 1000 allows the user program to give highest priority to SRQ's in this situation. A File Manager request may be used to set the S bit in the device configuration word for highest priority processing on SRQ interrupts:

```
:CN,19,25B,117000B
```

for LU 19.

```
        15 14 13 12 11 10  9  8  7  6  5  4  3  2  1  0
         S* R  D  I* J  O  P* E  X  X* X  X  X* X  X  X
        --*--------*--------*--------*--------*--------
         0  0  0  1  1  1  1  0  0  0  0  0  0  0  0  0
        --*--------*--------*--------*--------*--------
         0        1        7        0        0        0
        --*--------*--------*--------*--------*--------

E=0   HP-IB ERRORS WILL ABORT THE PROGRAM.

        15 14 13 12 11 10  9  8  7  6  5  4  3  2  1  0
         S* R  D  I* J  O  P* E  X  X* X  X  X* X  X  X
        --*--------*--------*--------*--------*--------
         0  0  0  1  1  1  1  1  0  0  0  0  0  0  0  0
        --*--------*--------*--------*--------*--------
         0        1        7        4        0        0
        --*--------*--------*--------*--------*--------

E=1   USER PROGRAM WILL HANDLE HP-IB ERRORS.
```

Figure 15-2. Example Device Configuration Words

[2] *The utility program BSCU (discussed in Appendix A) is used to observe the status of the HP-IB, including the configuration word.*

When high priority is given to SRQ interrupts (when SRQ is allowed to abort an I/O request), the R bit in the configuration word becomes effective. The R bit declares whether the I/O request, which was aborted, should be restarted. It is suggested that R be left at its default value (zero) for the 8672A.

DMA is not usually allocated for the 8672A. Typically, the two DMA channels in RTE are used for the faster devices in the system, such as tape drives and magnetic discs. Set bit 13 (the D bit) to zero in the device configuration word.

The I,J,O, and P bits all default to the correct value of '1'.

A typical configuration request from File Manager would be:

```
:CN,19,25B,117000B
```

for LU 19. See figure 15-3 for a description of each bit.

Remote

The 8672A must be set to remote operation before programming operations can begin. Remote is one of the HP-IB management lines; and once asserted, it will remain in that state until it is cleared. The remote enable command may be accomplished from File Manager (in the WELCOM file at boot-up) for example:

```
:CN,19,16B
```

for LU 19, or from the user FORTRAN program:

```
CALL RMOTE(19)
```

An example File Manager procedure file is shown in Figure 15-4.

```
        15 14 13 12 11 10  9  8  7  6  5  4  3  2  1  0
         S* R  D  I* J  O  P* E  X  X* X  X  X* X  X  X
        --*--------*--------*--------*--------*--------
         1  0  0  1  1  1  1  0  0  0  0  0  0  0  0  0
        --*--------*--------*--------*--------*--------
         1        1        7        0        0        0
        --*--------*--------*--------*--------*--------

S=1   I/O REQUEST ABORTS ON AN SRQ.
R=0   NO I/O RESTART ATTEMPT AFTER SRQ.
D=0   DMA IS NOT ALLOCATED FOR THIS DEVICE.
I=1   REQUIRE AN EOI FROM DEVICE WITH THE LAST BYTE.
J=1
O=1   ISSUE AN EOI WITH THE LAST BYTE.
P=1
E=0   HP-IB ERRORS WILL ABORT THE PROGRAM.
```

Figure 15-3. Configuration Evaluation

:SYLU,19,10,23B	Assign the logical unit number.
:CN,19,16B	Set the 8672A to remote.
:CN,19,25B,117400B	User program will handle errors, and SRQ has high priority.
:SYEQ,10,UN	Unbuffered operation.

Figure 15-4. An Example File Manager Procedure File

Programming

When the 8672A has been addressed to listen, the frequency, output level, AM modulation, FM deviation, and output leveling can be programmed. Programming is performed by sending pairs of ASCII characters, which consist of a program code and a value. The first character of the pair is the program code, and represents a specific frequency decade to be changed, or function to be performed (see figure 15-5). The second character of the pair represents the value within the frequency decade, or value of the function. The ASCII code pairs can be sent in arbitrary order with the exception of "frequency data" and the "frequency execute" command. They should be sent in alphabetical order.

For example, the following code pair sets the 8672A on LU 19 to the −50 dBm range:

```
      WRITE(19,101)
  101 FORMAT("K5")
```

When using multiple program codes to change several functions simultaneously, all program codes after the first may be omitted if the program codes are in alphabetical order without gaps.

For example, the following statements are equivalent, and sets the 8672A to 12.345678 GHz:

```
      WRITE(19,102)
  102 FORMAT("P1Q2R3 S4T5U6V7W8Z9")

      WRITE(19,103)
  103 FORMAT("P123 45678Z9")
```

Frequency Programming

Programming the frequency is straightforward. There are three basic steps:

1. Input the ASCII code pair for the largest digit being programmed.
2. Input the remaining frequency digits.
3. Input the frequency execute command and a dummy argument.

The frequency does not change until the frequency execute command is sent. In order to complete the programming syntax, a dummy argument must follow the frequency execute command, and can be any numeric value.

PROGRAM CODES		ASCII CHARACTER
FREQUENCY DECADE	10 GHz	@ or P
	1 GHz	A or Q
	100 MHz	B or R
	10 MHz	C or S
	1 MHz	D or T
	100 kHz	E or U
	10 kHz	F or V
	1 kHz	G or W
FUNCTION	FREQUENCY EXECUTE	J or Z
	RANGE	K or [
	VERNIER	L or \
	AM	M or]
	FM	N or ^
	ALC	O or _

Figure 15-5. 8672A Program Codes

For example,

```
      WRITE(19,104)
  104 FORMAT("P12345678J8")
```

results in 12345.678 MHz.

```
      WRITE(19,105)
  105 FORMAT("A9847600J2")
```

results in 9847.600 MHz.

```
      WRITE(19,106)
  106 FORMAT("P9847600J6")
```

results in an out of range indication of 98.476 GHz.

NOTE

In each of the above examples, the last digit was the dummy argument.

The 8672A has special features which can simplify programming in many situations.

a. Decimal points and blanks are ignored by the instrument. This allows a generalized format statement to be used to set frequency.

b. The frequency information is stored in two blocks of four digits each. One block is for the 10 GHz through 10 MHz digits, the other is for the 1 MHz through 1 kHz digits. Changes within one block does not change the other block unless it is necessary for the instrument to round the 1 kHz digit for frequencies above 6.2 GHz.

c. When digits are programmed within a block, all digits not being programmed are set to zero.

d. The frequency is stored in the memory until the frequency execute command is sent. This allows a frequency to be formed from multiple statements if desired, and executed when needed.

Output Level

There are two ASCII code pairs used to set output level. One pair sets the range in 10 dB steps, and the other sets the vernier in 1 dB steps. They can be used together when range and vernier are to be changed, or seperately when only one needs to be varied.

The range of output level can be controlled from 3 dBm to −120 dBm. The vernier setting can be controlled over a 13 dB range from +3 dB to −10 dB. The 13 dB programming range of the vernier is useful in applications where switching 10 dB ranges at certain output levels is undesirable. Figure 15-6 lists the arguments required for each range and vernier setting. Like frequency programming, any program code after the first can be omitted. That means to obtain an output level of −56 dBm, the program sequence could be either "K5L9", or "K59".

For example:

```
      WRITE(19,107)
  107 FORMAT("K03")
```

results in 0 dBm.

```
      WRITE(19,108)
  108 FORMAT("K:7")
```

results in −104 dBm.

Modulation

There are two ranges of amplitude modulation and six ranges of frequency modulation that can be remotely selected on the 8672A. These can be selected with the appropriate ASCII code pairs (see Figure 15-7).

For example:

```
      WRITE(19,109)
  109 FORMAT("M0N7")
```

results in no modulation.

```
      WRITE(19,110)
  110 FORMAT("M3N2")
```

results in 30% AM and 1 MHz FM.

Output Range (dBm)	Vernier (dB)	Argument ASCII
0	+3	Ø
−10	+2	1
−20	+1	2
−30	Ø	3
−40	−1	4
−50	−2	5
−60	−3	6
−70	−4	7
−80	−5	8
−90	−6	9
−100	−7	:
−110	−8	;
—	−9	<
—	−10	=

Figure 15-6. Arguments for Output Level

Range	Argument
Off	Ø or 1
100%	2
30%	3

Figure 15-7A. Amplitude Modulation Arguments

Range	Argument
Off	6 or 7
30 kHz	5
100 kHz	4
300 kHz	3
1 MHz	2
3 MHz	1
10 MHz	Ø

Figure 15-7B. Frequency Modulation Arguments

Leveling (ALC)

This ASCII code pair controls three different function switches. They are the RF ON/OFF switch, the ALC switch, and the +10 dBm range of output power. The desired combination can be found in figure 15-8. For example, "O1" will set RF ON, and use internal leveling within the normal power range.

Function	Argument
RF OFF	Ø, 2, 4, 6, 8, :, <, >
INT LEVELING, NORMAL RANGE	1
INT LEVELING, +10 dBm RANGE	3
EXT. XTAL LEVELING, NORMAL RANGE	5
EXT. XTAL LEVELING, +10 dBm RANGE	7
PWR MTR LEVELING, NORMAL RANGE	= (Decimal 61)
PWR MTR LEVELING, +10 dBm RANGE	? (Decimal 63)

Figure 15-8. ALC Arguments

NOTE

For proper instrument operation, whenever the +10 dBm overrange output is selected for the ALC program code, the argument for the OUTPUT LEVEL should be zero.

Service Requests

When normal instrument operation is disrupted for any of four reasons, the 8672A will request service via the interface SRQ line. The four conditions that will cause a request for service are:

1. If a programmed frequency is outside the instrument's capability. (OUT OF RANGE)
2. If the synthesizer is unlocked when the RF is on. (NOT PHASE LOCKED)
3. If the output is unleveled with the RF on, or an output level below −120 dBm is programmed. (LEVEL UNCALIBRATED)
4. If the FM is being overmodulated with the RF on. (FM OVERMOD)

When changing output level or frequency, several of the above conditions could occur for an instant during normal operation. This will temporarily cause a request for service until the synthesizer locks. The request for service will persist only as long as normal operation is disrupted or until a serial poll or parallel poll is initiated.

When addressed as a talker, the 8672A sends a status byte of eight bits which contains critical information on instrument operation. The coding of the status byte is shown in figure 15-9. As long as the 8672A is addressed to talk, it will continue to send a status byte. The CRLF is never sent. Therefore, when addressing the 8672A to talk, the number of bytes should be controlled.

As an aid in reading the status of the 8672A, figure 15-10 shows a listing of a device subroutine to read the 8672A and return the status to a calling program, or print it out in readable, English language. The comments at the beginning of the program explain how to use it.

The RSV Request Service bit is a "one" whenever any of the four conditions that cause a request for service exists (even during the first 50 ms after a programming change). Once the instrument is addressed to talk, the RSV line is fixed even though instrument operation may have changed.

The status byte is very useful for determining when a given programming change has been executed. For example, if the synthesizer is addressed to talk immediately after a frequency change, the status byte can be used to determine when the synthesizer has re-acquired lock. A frequency change might be followed by octal status bytes of 112,112,100 indicating the synthesizer is now locked.

Bit	8	7	6	5	4	3	2	1
Function	Crystal Oven Cold	RSV Request Service	Out of Range (Frequency)	RF Off	Not Phase Locked	Level Uncali-brated*	FM Over-mod	+10 dBm Over-range

Figure 15-9. 8672A Status Byte

```
FTN4,L
      SUBROUTINE S8672(IDLU,ILU), 8672 STATUS ROUTINE (NHK)
C
C     THIS IS A SUBROUTINE TO OBTAIN THE STATUS FROM AN 8672A
C     SYNTHESIZED SIGNAL GENERATOR.
C
C     THIS ROUTINE REQUIRES TWO PARAMETERS.  THE FIRST PARAMETER
C     IS THE LOGICAL UNIT OF THE 8672A.  THE SECOND PARAMETER IS
C     EITHER THE LU OF A LIST DEVICE, OR A DUMMY VARIABLE. IF THE
C     SECOND PARAMETER IS POSITIVE, THE STATUS WILL BE DECODED INTO
C     ENGLISH AND DISPLAYED ON THE LU.  IF THE SECOND PARAMTER VALUE
C     IS ZERO OR POSITIVE, THIS ROUTINE WILL REPLACE THE VALUE
C     WITH THE 8672 STATUS INFORMATION AND RETURN IT TO THE
C     CALLING PROGRAM WITHOUT TRANSLATION.
C
      CALL EXEC(1,100B+IDLU,ISTAT,-1)      This EXEC call obtains status in binary
      IF(ILU.LE.0) GO TO 900
      WRITE(ILU,111)
111   FORMAT( " 8672 STATUS")
100   FORMAT(15X,": CLEAR")
101   FORMAT(15X,": +10 DBM OVER-RANGE")
102   FORMAT(15X,": FM OVERMOD")
103   FORMAT(15X,": LEVEL UNCALABRATED")
104   FORMAT(15X,": NOT PHASE LOCKED")
105   FORMAT(15X,": RF OFF")
106   FORMAT(15X,": OUT OF FREQUENCY RANGE")
107   FORMAT(15X,": SRQ ASSERTED")
108   FORMAT(15X,": CRYSTAL OVEN IS COLD")
      IF(ISTAT.EQ.0)                  WRITE(ILU,100)
      IF(IAND(ISTAT,400B).GT.0)      WRITE(ILU,101)
      IF(IAND(ISTAT,1000B).GT.0)     WRITE(ILU,102)
      IF(IAND(ISTAT,2000B).GT.0)     WRITE(ILU,103)
      IF(IAND(ISTAT,4000B).GT.0)     WRITE(ILU,104)
      IF(IAND(ISTAT,10000B).GT.0)    WRITE(ILU,105)
      IF(IAND(ISTAT,20000B).GT.0)    WRITE(ILU,106)
      IF(IAND(ISTAT,40000B).GT.0)    WRITE(ILU,107)
      IF(IAND(ISTAT,100000B).GT.0)   WRITE(ILU,108)
      RETURN
900   ILU=ISTAT/377B
      RETURN
      END
```

Figure 15-10. Subroutine to Display 8672A Status

The 8672A is capable of performing both serial and parallel polls. For a serial poll, the synthesizer responds with its status byte when the bus is placed in the serial poll mode and the synthesizer is addressed to talk.

For a parallel poll response, the synthesizer is assigned one of the eight bus data lines on which to respond. Switch S1 (the parallel poll response switch) determines on which line the synthesizer will respond (see "Addressing"). Switch S4 (parallel poll sense) will determine whether the response will be a one, zero, or whether the parallel poll should be ignored.

Utility Routine for Setup

To help in setting up the 8672A, a simple utility routine is shown in figure 15-11. This program can be loaded to set up frequency, output level, AM, FM, and ALC for the 8672A under program control. The program is interactive, and prompts the operator for all of the answers. To load the routine, run the LOADR and include the utility and the status subroutine shown in figure 15-10. The name of the utility program is T8672. To run the program, enter:

```
:RU,T8672
```

```
FTN4,L
            PROGRAM T8672(3), 790222 8672A REMOTE SETUP (NHK)
            INTEGER IP(5),IBUF(5)
            DOUBLE PRECISION FREQ
            CALL RMPAR(IP)
            ITLU=IP(1)
            IF(ITLU.EQ.0) ITLU=1
            IBLU=IP(2)
            IF(IBLU.NE.0) GO TO 22
            WRITE(ITLU,101)
      101   FORMAT(/"WHAT IS THE LU OF THE 8672A?",/,"--> ")
            READ(ITLU,) IBLU
      22    WRITE(ITLU,102)
      102   FORMAT(/"WHAT FREQUENCY DO YOU WANT(IN MHZ)?",/,"--> ")
            READ(ITLU,) FREQ
            WRITE(ITLU,103)
      103   FORMAT(/"WHAT OUTPUT LEVEL DO YOU WANT(IN DBM)?",/,"--> ")
            READ(ITLU,) IDBM
            IDBM=3-IDBM
            WRITE(ITLU,104)
      104   FORMAT(/"CHOOSE AM MODULATION--",/"(1=OFF,2=100%,OR 3=30%)",/
           -"--> ")
            READ(ITLU,) IMOD
            WRITE(ITLU,105)
      105   FORMAT(/"CHOOSE FM DEVIATION--",/"(0=10 MHZ,1= 3MHZ,2=1MHZ)",/
           -"(3=300KHZ,4=100KHZ,5=30KHZ)",/"(6=OFF)",/"--> ")
            READ(ITLU,)IDEV
            WRITE(ITLU,106)
      106   FORMAT(/"CHOOSE LEVELING--",/,
           -"(0=INTERNAL,1=EXTERNAL,2=POWER METER)",/,"--> ")
            READ(ITLU,)IALC
            IALC=IALC4+1
            IF(IALC.EQ.1) IBUF2=1H1
            IF(IALC.EQ.5) IBUF2=1H5
            IF(IALC.GT.8) IBUF2=1H=
            CALL CODE
            WRITE(IBUF,107)FREQ
      107   FORMAT(F9.3)
            IBUF(1)=IOR(IBUF(1),10020B)
            IBUF(2)=IOR(IBUF(2),10020B)
```

Figure 15-11. Utility Routine to Remotely Set Up the 8572A.

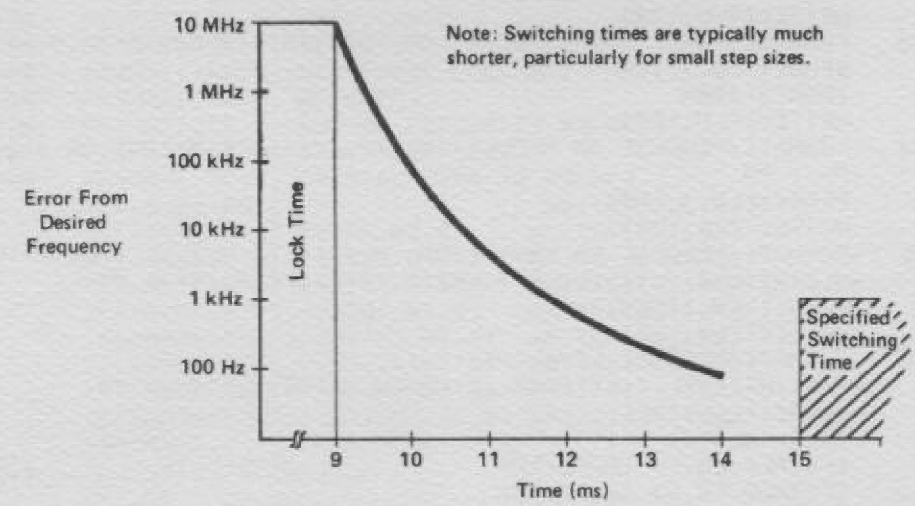
```
      IBUF(3)=IOR(IBUF(3),30000B)
      IF(IDBM.GT.9) GO TO 44
      WRITE(IBLU,108) IBUF,IDBM,IMOD,IDEV,IBUF2
      WRITE(ITLU,110) FREQ
110   FORMAT(" THE 8672A HAS BEEN SET TO ",F9.3," MHZ")
108   FORMAT("P",5A2,"Z9K0L",3I1,1A1,)
      GO TO 99
44    WRITE(IBLU,109) IBUF,IDBM,IMOD,IDEV,IBUF2
      WRITE(ITLU,110) FREQ
109   FORMAT(5A2,"Z9K",I2,2I1,1A1)
99    STOP
      END
```

Figure 15-11. 8672A Utility Routine (Continued)

Performance

Performance measurement for the 8672A is determined by two parameters: (1) the rate at which data can be input into the synthesizer over the interface, and (2) the time it takes the synthesizer to reach the desired output state. The 8672A can accept data at rates up to 80 kbytes/second. This data transfer time is only a small portion of total execution time. The more important consideration is the switching and settling time for proper frequency, output level, and modulation.

The time it takes to switch from one frequency to the next depends on the amount of frequency change. Generally, as the difference between frequencies decreases, the shorter the switching time. Typical switching time for frequency, level, and modulation are shown in figure 15-12.



Output Level Programming

Output range switching (10 dB steps) .... <20 ms
Output vernier switching (1 dB steps) .... <10 ms
RF ON/OFF switch ON .... <30 ms
OFF .... < 5 ms

Modulation Programming

FM range change and frequency changes in
FM mode .... <750 ms
AM range change .... <15 ms

Figure 15-12. Typical Frequency Switching Times

NOTES

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